

## Preprocessing of Hinode/SOT vector magnetograms for nonlinear force-free coronal magnetic field modelling.

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**Abstract.** The solar magnetic field is key to understanding the physical processes in the solar atmosphere. Nonlinear force-free codes have been shown to be useful in extrapolating the coronal field from underlying vector boundary data (see Schrijver et al. 2006, for an overview). However, we can only measure the magnetic field vector routinely with high accuracy in the photosphere with, e.g., Hinode/SOT, and unfortunately these data do not fulfill the force-free consistency condition as defined by Aly 1989. We must therefore apply some transformations to these data before nonlinear force-free extrapolation codes can be legitimately applied. To this end, we have developed a minimization procedure that uses the measured photospheric field vectors as input to approximate a more chromospheric like field (The method was dubbed preprocessing. See Wiegmann et al. 2006, for details). The procedure includes force-free consistency integrals and spatial smoothing. The method has been intensively tested with model active regions (see Metcalf et al. 2007) and been applied to several ground based vector magnetogram data before. Here we apply the preprocessing program to photospheric magnetic field measurements with the Hinode/SOT instrument.

### 1. Results

The original Hinode vector magnetogram ( $B_x, B_y, B_z$  components of the photospheric magnetic field vector, respectively) is shown in the top panel of Fig. 1. The solar photosphere has a plasma  $\beta$  of about unity and non-magnetic forces like pressure gradients and gravity are important here. Consistent boundary conditions for a nonlinear force-free extrapolation of the coronal magnetic field require, however, that the net force on the boundary vanishes. We introduce a dimensionless number which measures the net forces, normalized by the photospheric magnetic field strength:

$$\epsilon_{\text{force}} = \frac{|\int_S B_x B_z dx dy| + |\int_S B_y B_z dx dy| + |\int_S (B_x^2 + B_y^2) - B_z^2 dx dy|}{\int_S (B_x^2 + B_y^2 + B_z^2) dx dy},$$

and only for  $\epsilon_{\text{force}} \ll 1$  the boundary conditions are consistent with a nonlinear force-free coronal magnetic field. We find  $\epsilon_{\text{force}} = 0.16$  for the original photo-

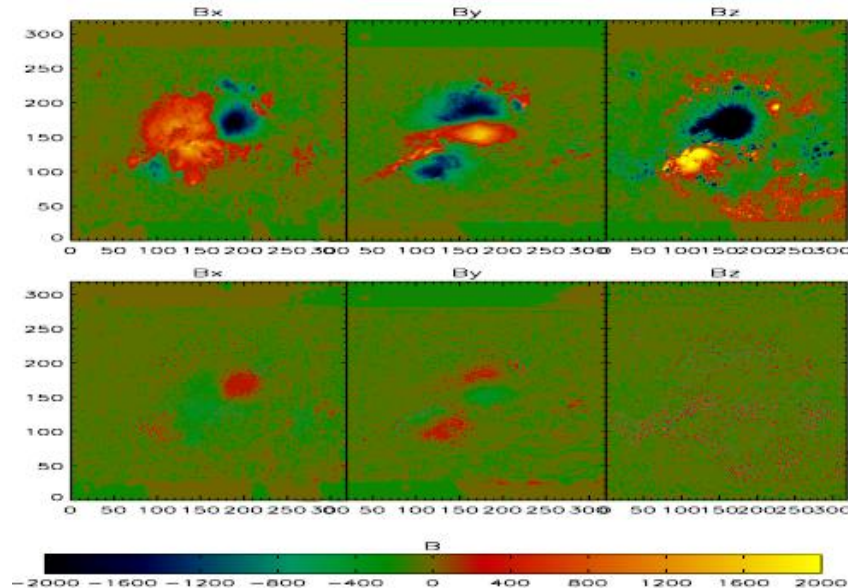


Figure 1. Top: Photospheric vector magnetogram data measured with the Hinode/SOT instrument for a flaring active region, december 12, 2006. Bottom: Difference between the original and the preprocessed data. The preprocessed dataset provides us suitable boundary conditions for a nonlinear force-free extrapolation of the coronal magnetic field.

spheric Hinode magnetogram. This is significantly better compared to ground based observations, where one finds values up to about unity, but still not sufficient in order to use the data as boundary conditions for a force-free magnetic field extrapolation directly. After applying the preprocessing procedure we find  $\epsilon_{\text{force}} = 1.8 \cdot 10^{-4}$ , almost three orders of magnitude lower than the original data. This preprocessed vector magnetogram (and also the one of the following day) has been used as boundary condition for nonlinear force-free computations of the coronal magnetic field before and after an X-class flare (Schrijver et al., ApJ in preparation).

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